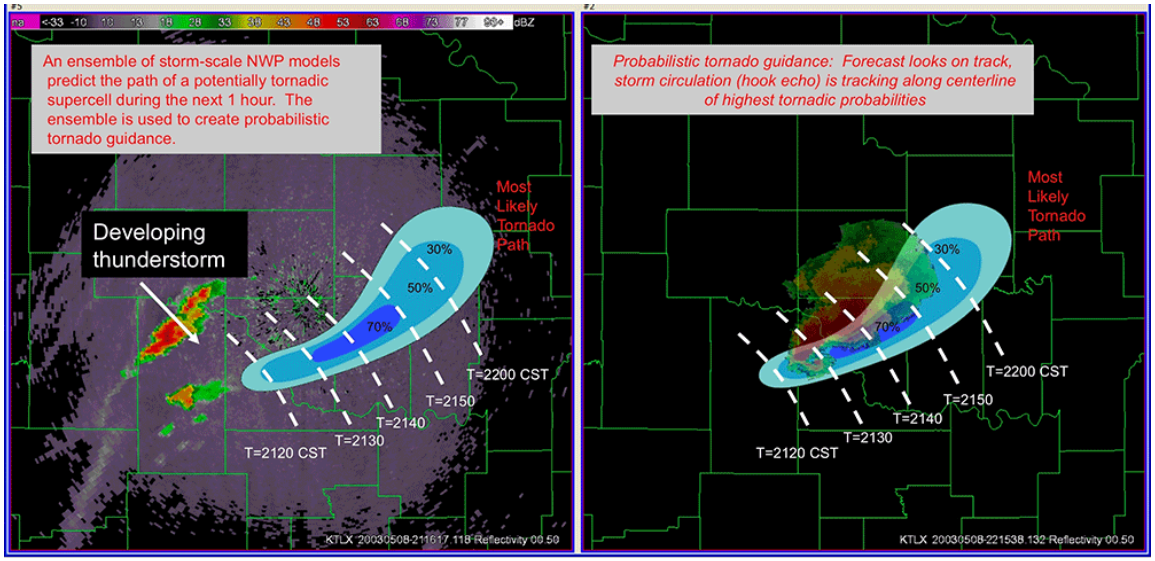
NOAA National Severe Storms Laboratory

Warn-on-Forecast

NOAA's Warn-on-Forecast research project aims to create weather computer-models that accurately predict storm-scale phenomena such as tornadoes, large hail, and extreme localized rainfall. If Warn-on-Forecast is successful, forecasters will have reliable guidance for issuing tornado, severe thunderstorm, and flash flood warnings up to an hour before they strike.



Warn on detection (The present)

Currently, the NOAA National Weather Service (NWS) does not issue warnings for local severe weather until they see an early signal on radar, or the weather hazard is spotted. This approach provides the public with an average of 13 minutes advance notice before a tornado strikes. For some needs, this is not enough lead-time to move people to safety.

Warn-on-Forecast (The future)

Warn-on-Forecast (WoF) researchers work to combine high-resolution surface, satellite, and radar data into an optimal set of analyses to initialize ultra-high resolution computer models that will predict specific weather hazards 30-60 minutes before they form. This advanced modeling system will predict probabilities of a hazard occurring, the confidence in the path, and adjust to trends in the threat level based on new weather observations, and rapid and adaptive radar scanning capabilities. Researchers are now working with a prototype system that uses rapid-scanning Multi-function Phased Array Radar to predict the path of a potentially tornadic supercell.

Warn-on-Forecast and FACETs

Warn-on-Forecast is the foundation of the new Forecasting a Continuum of Environmental Threats (FACETs), a proposed next-generation severe weather forecasting concept. FACETs aims to build a modern, flexible system that forecasters can use to communicate user-specific, understandable weather threat information. FACETs will serve as a "delivery mechanism" for WoF predictions of storm-specific hazards such as tornadoes, large hail, and extreme local rainfall. This work will enable the current NWS warnings paradigm to move beyond a binary yes/no warning process (from being in or outside the warning polygon) toward one which provides a more detailed threat assessment allowing various classes of users to base decisions on their specific situations and vulnerabilities. Decision-makers could set their own hazardous weather threat thresholds based on their specific needs.

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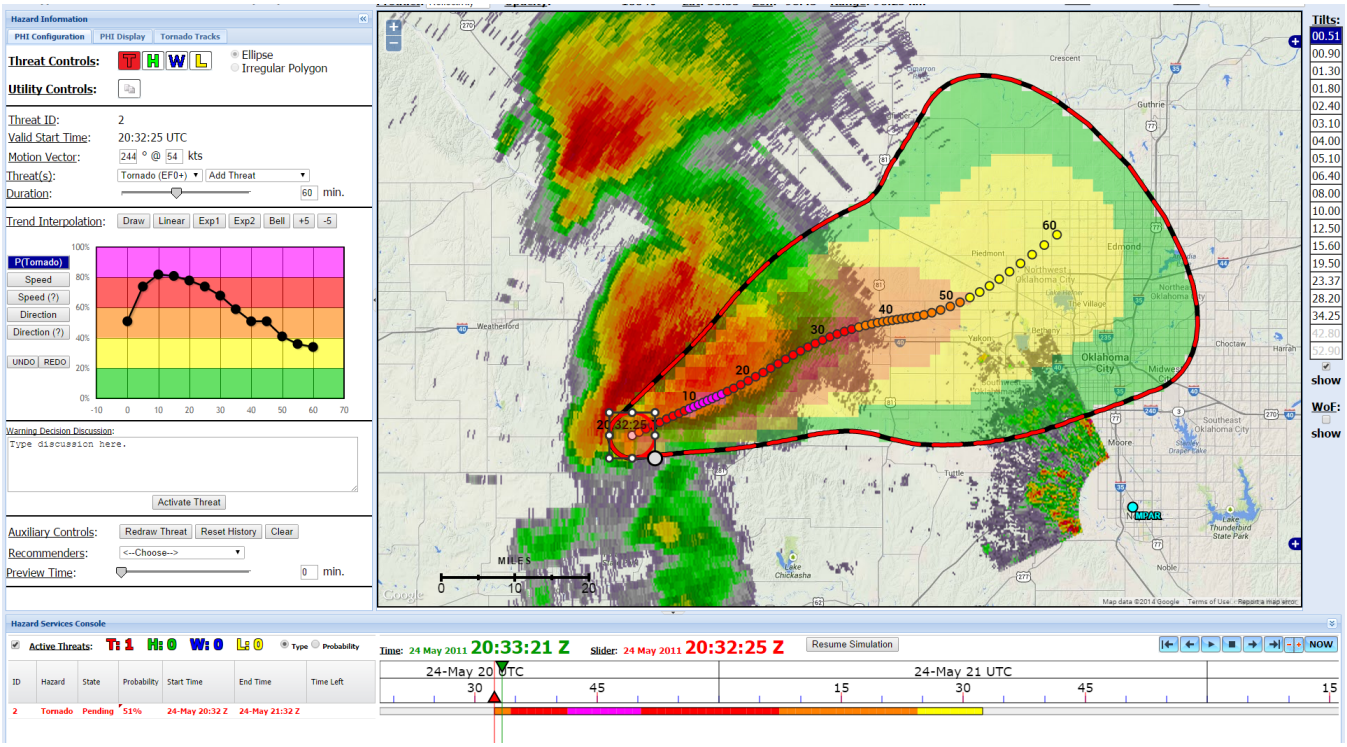


This prototype Probabilisitic Hazard Information tool used MPAR data from WoF guidance for the El Reno, Okla. EF-3 tornado on 24 May 2011. The forecast uncertainty is implied by the gridded probability field, with the most likely path indicated by the dotted line.

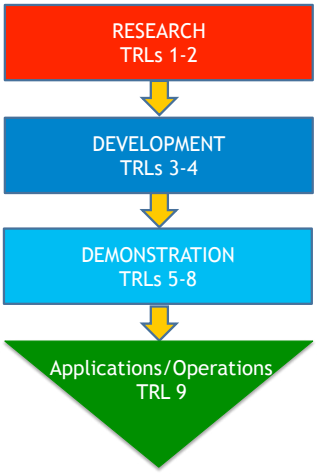
Testing the Warn-on-Forecast concept

As new Warn-on-Forecast technologies emerge, they are tested in simulated forecasting and warning exercises in the NOAA Hazardous Weather Testbed (HWT), ensuring an efficient transition into forecasting operations. In the HWT, Warn-on-Forecast scientists and NWS forecasters have already evaluated multiple building blocks of a future Warn-on-Forecast system, including: 1) Phased Array Radar and its ability to provide more frequent updates than current NWS radars, 2) different techniques to feed radar data into forecast models accurately and quickly, 3) different suites of forecast models that can be combined into a single system representing all possible outcomes for a given weather event, and 4) development of strategies that allow forecasters to rapidly interpret computer-model guidance and add value in generating prototype forecast products.

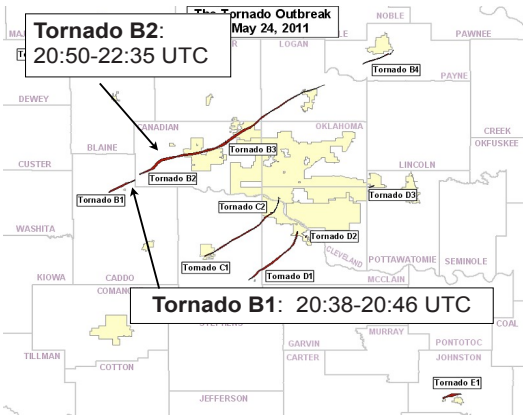
Warn on Forecast R20 "Schedule"

NWS/OST/MDL Technology Readiness Level (TRL) Framework

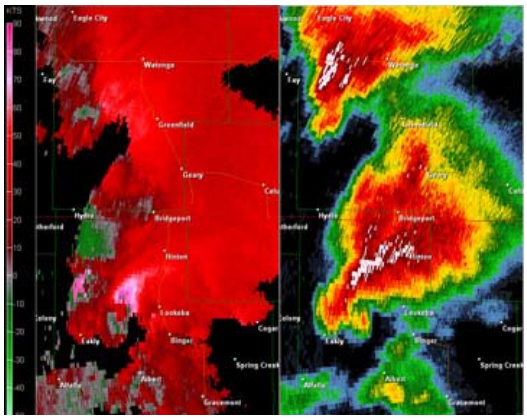
- NOAA projects move through four life-cycle phases on their way to (and including) application/operations
- Warn-on-Forecast began as a Research project (TRL=1) in mid-2010
- Now transitioning to the Development level (TRL=3) in FY15-16 (via HWT)
- Warn on Forecast could be at a Demonstration level (TRL=5) by FY19, depending on funding.
- Current EMC plans have Warn-on-Forecast operational around FY23.
- Due to computational constraints, WoF's initial implementation will likely be an on-demand prediction system similar to the HWRF system today.



MPAR Impact on Warn-on-Forecast Case Study: May 24, 2011 El Reno, OK EF-5 Tornado



Tornado Track Summary for 24 May 2011. MPAR radar focused on the supercell producing tornadoes B1 and B2.

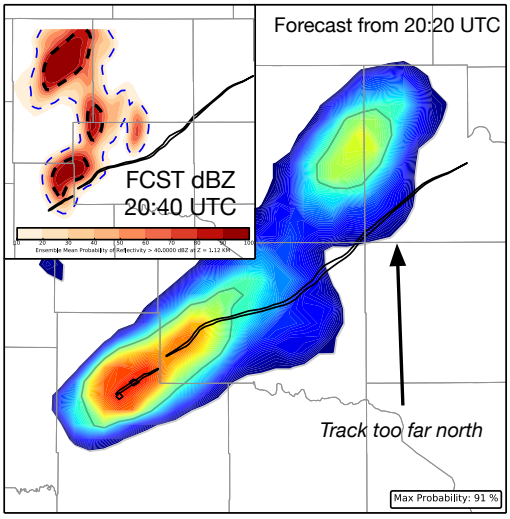


NWS radar from Oklahoma City at 20:40 UTC when tornado B1 is on the ground. Dopper radar (left) and reflectivity (right) are shown.

El Reno, OK EF-5 tornado

- Duration: 20:50-22:35 UTC (1 hour 45 minutes)
- Distance Traveled: 101 km
- Fatalities: 9

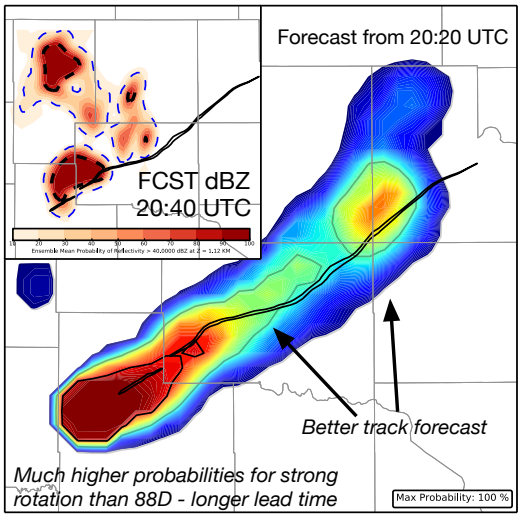
1 Hour Forecast Rotation Tracks using WSR-88D Data

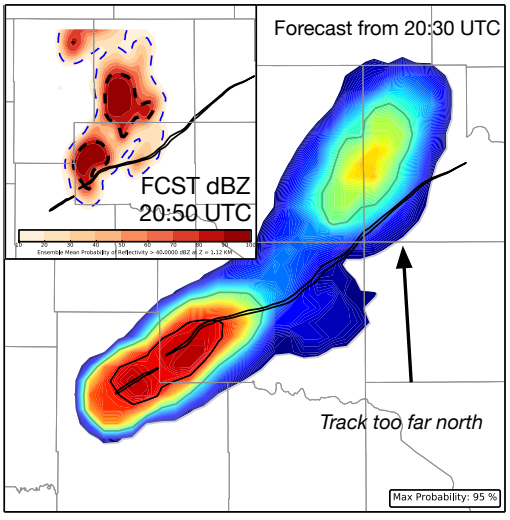


Left: One hour probability swaths for strong low-level rotation using WSR-88D 5 minute data in WoF predictions. Forecast begins 20:20, ends at 21:20 for El Reno supercell. The inset plot shows the ensemble probabilities of reflectivity exceeding 40 dBZ. The black dashed line depicts ensemble mean 40 dBZ contour. A 20 minute forecast for dBZ is shown.

Right: One hour probability swaths for strong low-level rotation using MPAR 1 minute data in WoF predictions. Forecast begins 20:20, ends at 21:20 for El Reno supercell. The inset plot shows the ensemble probabilities of reflectivity exceeding 40 dBZ.

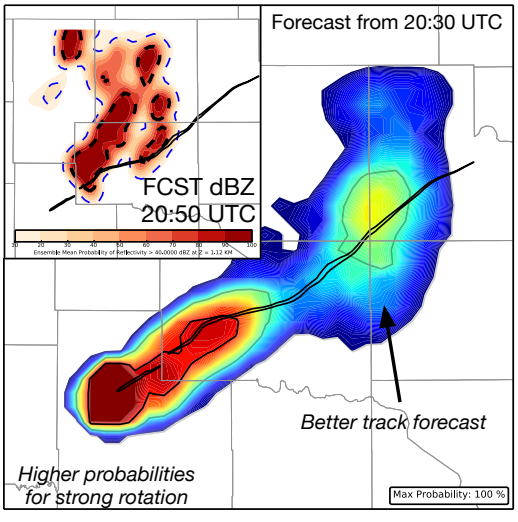
1 Hour Forecast Rotation Tracks using MPAR Data

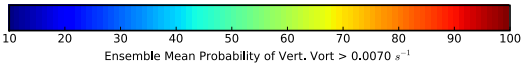


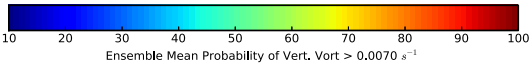


Left: Same as upper left panel, except the forecast is now started at 20:30 UTC.

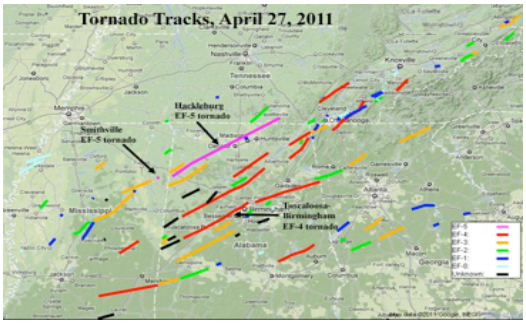
Right: Same as upper right panel, except the forecast is now started at 20:30 UTC.

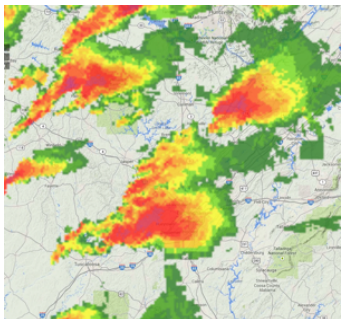






Warn-on-Forecast case study: April 27, 2011 Alabama tornado outbreak





Hackleburg-Phil Campbell-Tanner EF-5 tornado

- Duration: 2005-2220 UTC (2 hours 15 minutes)
- Distance Traveled: 212 km
- Fatalities: 72

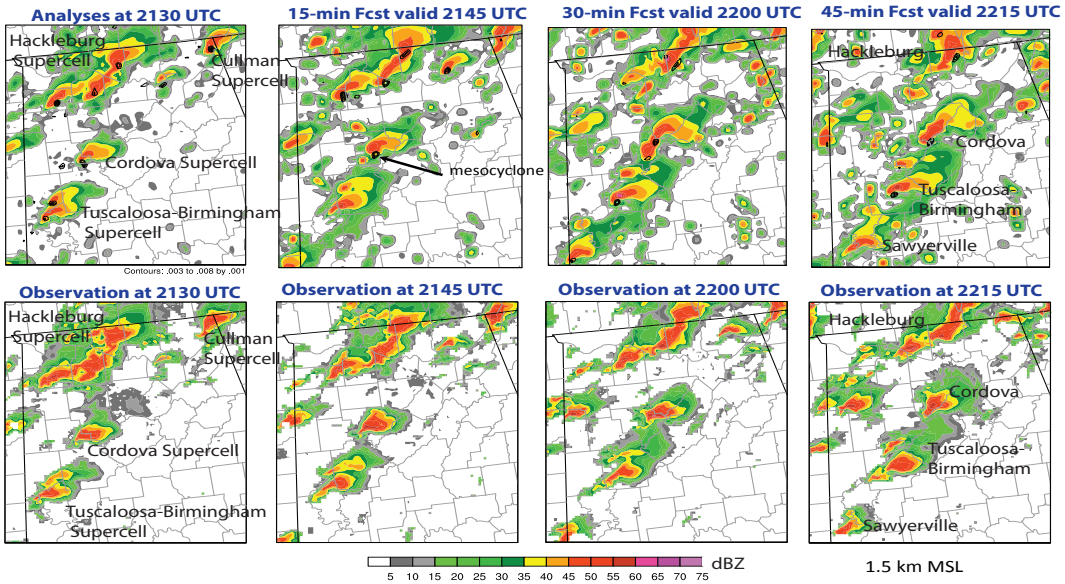
Tuscaloosa to Birmingham EF-4 tornado

- Duration: 2143-2214 (1 hour 30 minutes)
- Distance Traveled: 130 km
- Fatalities: 65

Cordova EF-4 tornado

- Duration: 2040-2250 (2 hours 10 minutes)
- Distance traveled: 205km
- Fatalities : 13

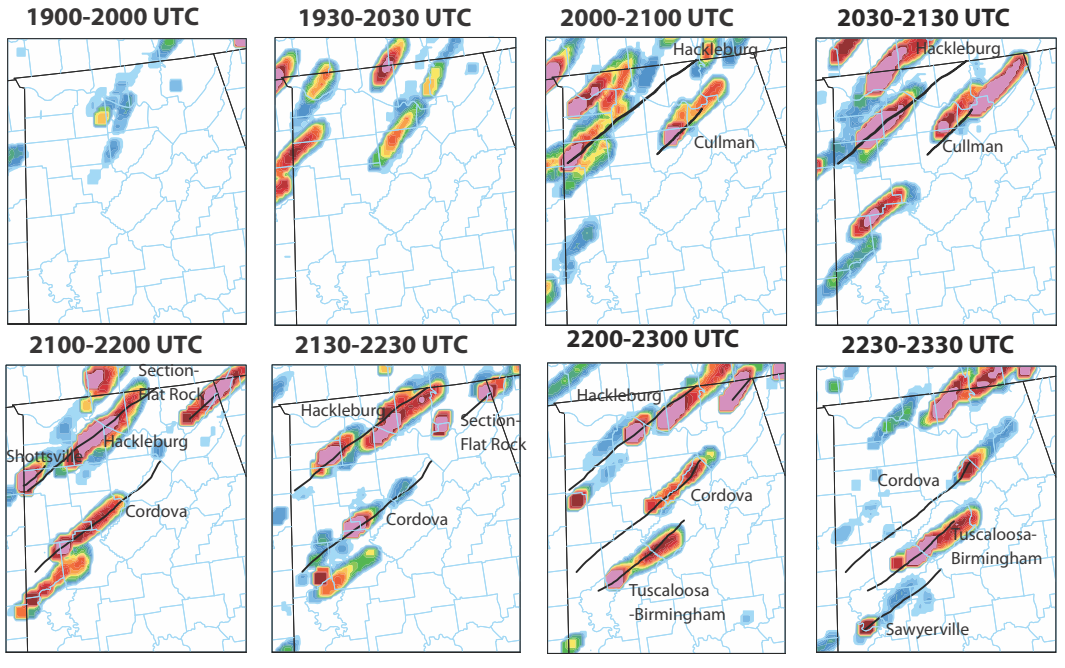
Reflectivity forecasts from 2130 UTC Analyses



Top row: Predicted mean reflectivity fields from Warn-on-Forecast prototype ensemble system shown every 15 minutes from 21:30 through 22:15. Major supercell/tornado families are labeled.

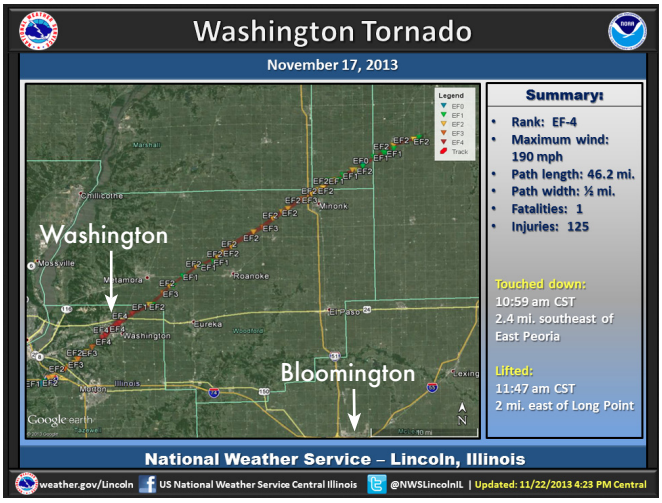
Bottom Row: Analyzed reflectivity observations from 27 April 2011 with major supercell/tornado families labeled.

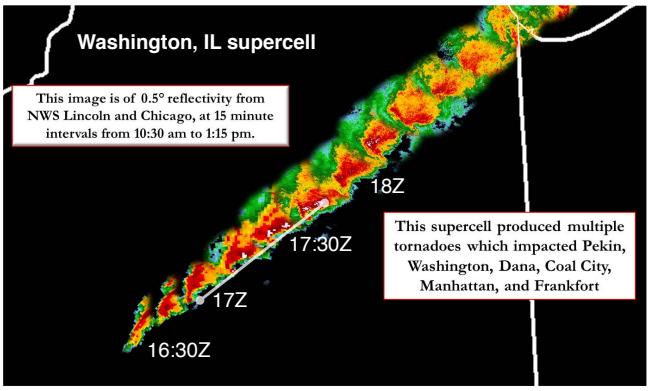
0-1 hr Forecast Probability of Low-Level Rotation every 30-min



One hour probabilistic prediction of strong low-level rotation from Warn-on-Forecast prototype ensemble system. A new probabalistic ensemble forecast for low-level rotation is generated and shown 30 minutes apart. Major supercell/tornado families are labeled. Red or pink probabilities depict near 90-100% probability of strong low-level rotation. Observed tornado tracks are also shown for the major supercell/tornado families.

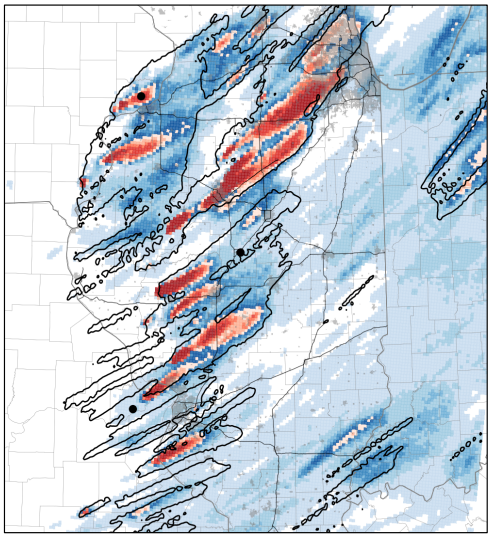
Warn-on-Forecast case study: November 17, 2013 Washington, IL (cold season)



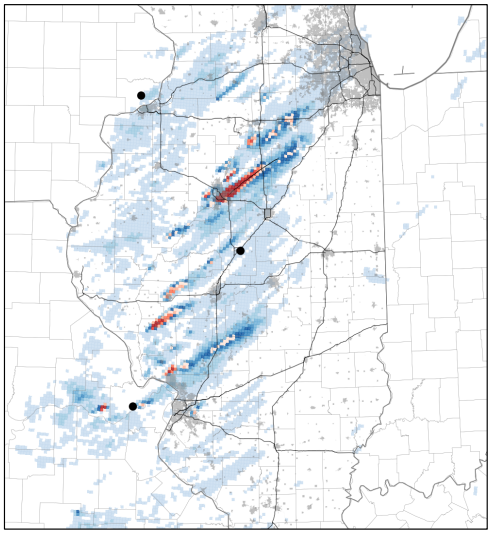


Images from NWS Chicago/Lincoln

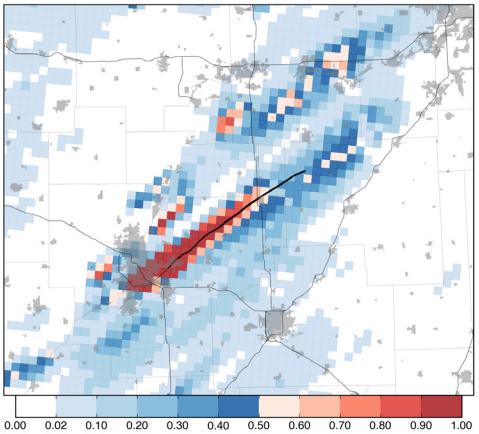
Above: Time series of NWS Lincoln radar every 15 mintues (16:30-18:15 UTC).

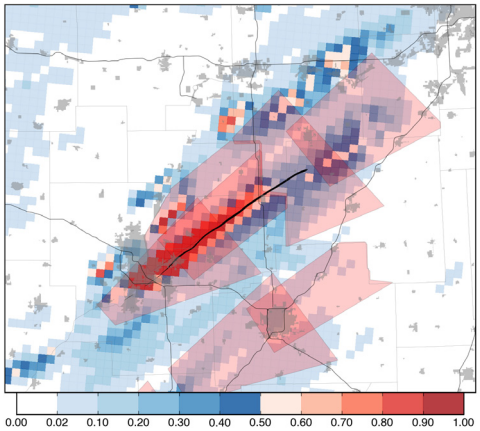


Ensemble probabilities of radar echoes > 40 dBZ near ground 17:00-18:00 UTC. Red colors indicate highest probabilities (80-100%). Black contours outline the actual observed area of 40 dBZ echo paths from the radar during the 1 hour period.



Ensemble probabilities of rotation near the ground from 17:00-18:00 UTC. Probability of 0-1 Updraft Helicity >2m^{2}s^{-2}. Red colors indicate highest probabilities (80-100%) for strong low-level rotation.





(Far left) Zoomed in view of rotation probabilities for central IL from 17:00-18:00 UTC. Washington supercell forecast has high probabilities for rotation. Another storm is located SW of the Washington storm, little rotation is forecasted.

(Left) Zoomed in view of rotation probabilities combined with tornado warnings issued for central IL from 17:00-18:00 UTC. Note the two distinct sets of tornado warnings, one is for the Washington supercell, the other the Bloomington supercell where little rotation is predicted.